

Potential health benefits of aloe vera

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Abstract

Introduction and aim: Aloe vera was known in antiquity, and then its versatile healing and cosmetic properties were used. It is a rich source of many chemical compounds; it has been shown that there are 75 biologically active compounds, i.e. vitamins, minerals, enzymes, sugars, phenolic compounds, sterols, amino acids. The aim of this article was to review the literature and gather information on the health benefits of aloe vera and its products.

Brief description of the state of knowledge: There are many studies in the available literature on the influence of aloe vera and its products on human health. Studies carried out with the use of an aloe gel extract have shown that methanol and acetone solutions have maximum radical scavenging abilities. Other sources report that the use of aloe vera had a beneficial effect on the treatment of first and second degree burns, in addition the use of aloe vera gel in 63 male wounded rats increased the healing power of wounds than in other groups. Aloe vera juice is useful in the treatment of gastrointestinal problems, such as indigestion, yeast, heartburn and

irritable bowel syndrome. Aloe vera extract increased cell tolerance to glucose in healthy and diabetic rats, and the use of aloe vera juice (4 - 14 weeks) had a significant hypoglycemic effect.

Summary: The collected literature data show that aloe vera, as well as its products have a beneficial influence of human health. They exhibit properties such antioxidant, anti-inflammatory, anti-cancer, antimicrobial, immunomodulatory, lipid and blood sugar lowering properties, and also accelerate the healing of wounds and burns. Aloe vera also has a beneficial effect on people's appearance (skin, hair, nails), thanks to which it finds a wide use in the cosmetics industry. Despite so many benefits, people should pay attention to the side effects of using aloe vera. It is also important to continue research (both with animals and people) related to the influence of this plant and its products on health.

Key words: aloe vera, health benefits, aloe vera leaves, aloe vera gel, aloe vera juice

Introduction

Aloe vera plant belongs to the *Liliaceae* family and comes from southern and eastern Africa, then it was introduced to the northern regions as well as to other countries around the world. Commercial cultivation of plant includes Aruba, Bonaire, Haiti, India, South Africa, the United States and Venezuela [61]. However, the best quality aloe vera plant comes from the desert of southern California [46]. Several names of this plant are known i.e. Aloe, Aloe vera, Aloe capensis, Aloe spicata, Barbados loe, Cape aloe; the names are various and depend also on the country of cultivation or origin e.g. Chirukattali (India), Laloï (Haiti), Lohoi (Vietnam), Luhui (China), Rokai (Japan), Sabilla (Cuba) [6]. The use of aloe vera is very wide by the industry, in particular by such branches as food and cosmetics [Tab. 1].

Tab. 1. Industrial use of aloe vera.

| Uses of aloe vera | reference |
|--|-----------|
| <i>Food industry</i> | |
| <i>Concentrate</i> | |
| jam, jellies, addition to tea, water or juice | [2] |
| <i>Gel</i> | |
| bar, chewing gum, instant aloe vera tea granules, candy type aloe vitamins, aloe vera fruit smoothies | [2] |
| <i>Juice</i> | |
| drinks (health, soft, laxative), sports drink (with electrolytes), diet drink (with soluble fiber), hangover drink (with B-vitamins), vegetable juice mix, mix for alcohol (whiskey), bread, yoghurt | [2] |
| <i>Powder</i> | |
| yoghurt, curd, ice-cream | [2] |
| <i>Cosmetics industry</i> | |
| creams, lotions, herbal masks | [12, 25] |
| soaps, bath lotions, emulsions for and after tanning | [25] |
| deodorant | [12] |
| tonic | [45] |
| <i>Pharmaceutical industry</i> | |
| preparations treating skin lesions, anti-dandruff shampoos, anti-hair loss products | [24] |

Aloe vera is a very short plant that grows to 60-100 cm in height [6]. The leaves are lanceolate, thick and fleshy, take the color from green to gray-green, and also have serrated edges. The tissue in the middle of the leaf contains a gel commonly called aloe vera gel. Flowers are present on the spine of the plants and are characterized by a yellow cylindrical crown with a length of 2-3 cm [26]. The raw pulp of aloe vera occurs about 99% of water, whereas the residue (0.5 - 1%, according to some references even up to 4%) contains a number of various chemical compounds [31]. The share of selected chemical compounds in lyophilized aloe vera plant fractions was presented in Table 2 (basic chemical compounds, minerals) and Table 3 (phenolic compounds).

Tab. 2. Chemical characterisation of lyophilised aloe vera plant fractions [17].

| Chemical compounds | Skin | Filet | Gel |
|---------------------------------|----------------|-------|-------|
| | [% dry matter] | | |
| <i>Basic chemical compounds</i> | | | |
| Lipids | 2.71 | 4.21 | 5.13 |
| Proteins | 6.33 | 7.26 | 8.92 |
| Souble sugars | 11.22 | 16.48 | 26.81 |
| Dietary fiber | 62.34 | 57.64 | 35.47 |
| Ash | 13.46 | 15.37 | 23.61 |
| <i>Minerals</i> | | | |
| Ca | 4.48 | 5.34 | 3.58 |
| Mg | 0.90 | 0.76 | 1.22 |
| Na | 1.82 | 1.98 | 3.66 |
| K | 1.84 | 3.06 | 4.06 |
| P | 0.01 | 0.01 | 0.02 |
| Fe | 0.04 | 0.04 | 0.10 |
| Cu | 0.02 | 0.04 | 0.06 |
| Zn | 0.02 | 0.02 | 0.02 |

Tab. 3. Phenolic compounds of lyophilised aloe vera plant fractions [12].

| Phenolic compounds | Skin | Flowers |
|---------------------------------|------------|---------|
| | [mg/100 g] | |
| <i>Phenolic acids</i> | | |
| Sinapic | 54.00 | 15.00 |
| Gallic | 0.00 | 12.60 |
| Protocatechuic | 11.22 | 16.48 |
| Vanillic | 2.30 | 0.80 |
| Syringic | 4.90 | 5.00 |
| Chlorogenic | 7.80 | 2.80 |
| Gentisic | 6.00 | 101.00 |
| Caffeic | 4.90 | 9.30 |
| Coumaric | 0.80 | 7.60 |
| Ferulic | 7.90 | 3.10 |
| <i>Flavonoids</i> | | |
| Quercetin | 23.00 | 31.90 |
| Kaempferol | 4.03 | 2.90 |
| Apigenin | 3.30 | 3.00 |
| Catechin | 95.00 | 7.60 |
| Epicatechin | 16.20 | 58.00 |
| Rutin | 22.30 | 11.60 |
| Myricetin | 19.60 | 1.80 |
| Quercetin | 34.40 | 0.00 |
| <i>Total phenolic compounds</i> | | |
| Total | 307.50 | 274.50 |

The plant contains many vitamins necessary for the human body (A (provides proper visual processes), B₁ (important factor in carbohydrate burning reactions in cells), B₂ (participates in the proper functioning of the nervous system), C (involved in the production of collagen and basic proteins throughout organism), E (protects cells against unfavorable oxidation processes), B₃, B₆, B₁₂, folic acid, choline) and minerals (phosphorus (involved in building bones and teeth), potassium (helps to maintain fluid balance in organism), iron (involved in oxygen transport and hemoglobin production), sodium (responsible for regulating body fluids), copper (important for red blood cells, skin and hair pigments), magnesium, calcium, chromium, zinc) [27, 46, 47]. Aloe vera also contains traces of minerals such as rhodium and iridium used in tumor neuropathy [39]. This plant is a wealth of amino acids, both exo- and endogenous, i.e. alanine, arginine, cysteine, isoleucine, methionine, phenylalanine, threonine, valine, aspartic

acid, glutamic acid, proline, serine, and tyrosine [59]. Scientific experiments have shown that the enzymes present in aloe vera are amylase (breaks down sugars and starches), bradykinase (stimulates the immune system, analgesic, anti-inflammatory), catalase (prevents the accumulation of water in the body), lipase (supports digestion of fat), creatine phosphokinase (supports metabolism), carboxypeptidase, cellulase, oxidase, alkaline phosphatase and proteolytisase [62]. An important component of aloe vera is also lignin (beneficial for skin problems such as eczema and psoriasis). Other ingredients present in aloe vera are mono- and polysaccharides (mannose, glucose, pectin, hemicellulose, glucomannan, acemannan derivatives) [23, 11], sterols (lupeol, campesterol, β -sitosterol), hormones (auxins, gibberellins), tannins, resins, proteins (lectins, monosulfonic acid), as well as saponins (soapy substances have antiseptic and cleansing properties) [3, 39] and organic acids (especially salicylic acid which have anti-inflammatory and antibacterial properties) [39]. It is generally estimated that 12 different anthraquinones of aloe origin have been isolated and described (up to now) [16, 31], this compounds belong to a phenolic group and they are known from laxatives properties [3]. The content of fatty acids in aloe vera reaches almost 3%, in them are saturated (arachidonic, myristic, caprylic, palmitic, stearic), and unsaturated fatty acids (linoleic, linolenic) [38]. These fatty acids are plant steroids, and they have the anti-inflammatory, antiseptic and analgesic properties [3].

Aloe vera is considered a wonderful plant because of its healing potential for human ailments. The medicinal and pharmacological properties of aloe vera are due to the chemical composition, it is estimated that as many as 75 compounds present in aloe vera have biologically active properties [3]. The aim of this article was to review the literature and gather information on the health benefits of aloe vera and its products.

Health benefits of aloe vera and its product

Antioxidant properties

Aloe vera is a great example of functional food that plays a significant role in protection against oxidative stress [23, 16]. Its action is related to the reduction of the process of cell destruction during stress, and also minimizes biochemical and physiological changes in the body [23].

The antioxidative action of aloe vera gel extracts made in methanol, 95% ethanol, hexane, acetone and chloroform were tested *in vitro*. The results showed that methanol and acetone extracts had the maximum capture of DPPH free radicals and superoxide radicals. All extracts were effective in the replacement of hydroxyl radicals in a non-ion specific test as well as in a place-specific assay. It was also found that the formation of ferrozinium- Fe^{2+} complex is

incomplete in the presence of methanol and acetone, which indicates their ability to chelate iron [50]. Similar conclusions were observed in research conducted by Rahmani et al. [42] and Athiban et al. [4]. Moniruzzaman et al. [36] reported that ethanol skin extracts of aloe vera contain the highest phenol content and flavonoid content, which clearly confirms high DPPH scavenging activities and FRAP values and indicates the potential use of this plant as an antioxidant.

The antioxidant properties of aloe vera were also found in rodent model studies, which were fed regularly with plant leaves. The results obtained in this experiment showed an increased activity of antioxidant enzymes and a reduced content of lipid peroxidation products in animal tissues [6, 12].

Antibacterial properties

Saritha et al. [51] studied the antibacterial activity of various aloe vera gel extracts (methanol, ethanol, acetone, hexane, chloroform). Based on the results, they found that the methanolic extract of the gel showed a significant zone of inhibition of all used pathogens and the results were comparable to conventional antibiotics. In addition, literature data suggest that the aloe vera gel is characterized by bactericidal activity against *Pseudomonas aeruginosa* [1, 5], *Streptococcus pyogenes*, *Streptococcus faecalis* [19], *Mycobacterium fortuitum*, *Mycobacterium smegmati* and *Mycobacterium kansasii* [33], this effect was also demonstrated against *Escherichia coli*, *Staphylococcus aureus* and *Salmonella typhi* [40].

It has been proven that compounds present in aloe vera such as glucomannan and acemannan activate macrophages, stabilize the immune system and have an antibacterial effect [40], while anthraquinones act in a similar way to tetracycline - antibiotic with a broad spectrum of antibacterial that inhibits bacterial protein synthesis, blocking the aminoacyl site (site A) in ribosomes, where tRNA molecules attach to mRNA [41, 48].

Antifungal properties

The purpose of the Shireen et al. [53] research was to determine the antifungal activity of the extract of aloe vera on *Candida albicans*. The results simultaneously indicate good antifungal properties of the leaf extract, although the inhibitory effect was dependent on the concentration, 1000 µg/ml was the most effective. De Rodríguez et al. [15] investigated the effect of aloe vera on the development of fungi such as *Rhizoctonia solani*, *Fusarium oxysporum* and *Colcotrotrich coccodes*. It demonstrated that an inhibitory effect of the aloe vera parenchyma on *Fusarium oxysporum* (at a concentration of 10⁴ µl/L), while the liquid fraction significantly reduced the

colony growth rate in *Rhizoctonia solani*, *Fusarium oxysporum* and *Colletotrichum coccodes* (at a concentration of 10^5 µl/L).

Sitara et al. [54] reported that aloe vera gel extracted from leaves (at a concentration of 0.15%, 0.25% and 0.35%) has the ability to inactivate pathogenic fungi such as *Aspergillus niger*, *Aspergillus flavus*, *Alternaria alternata*, *Drechslera hawaiiensis* and *Penicillium digitatum*, but the highest concentration of aloe vera gel completely inhibiting the growth of *Drechslera hawaiiensis* and *Alternaria alternata*. Literature also indicates that aloe vera is also active against *Colletotrichum gloeosporioides* and *Cladosporium cucumerinum* [34].

Antiviral properties

Several scientific studies have shown that aloe vera gel is an effective antiviral agent. Research conducted by Kemp et al. [24] about the antiviral properties of acemannan (present in the gel) confirmed that it limits the occurrence of a viral infection caused by herpes simplex virus (carried out in cell culture). Saoo et al. [50] analyzed the antiviral properties of lectins (aloe vera gel fraction) and based on the results, they found that lectins can inhibit cytomegalovirus proliferation (also carried out in cell culture). It has also been shown that purified aloe emodin is effective against not only the infectivity of herpes simplex virus type I and type II, but also inactivated other viruses, i.e. chickenpox virus and influenza virus [56].

Anti-inflammatory properties

The anti-inflammatory effects of aloe vera gel have been revealed in many in vitro and in vivo studies [46]. The enzyme, bradkinase, was isolated from aloe vera, it is able to break down bradykinin (an inflammatory substance which induces pain) [21]. From aloe vera extract a new compound, C-glucosyl-chromone, was also obtained, it has been shown that it has strong anti-inflammatory properties. In addition, an aloe steroid (containing campesterol, lupeol, β -sitosterol and cholesterol) helps in reducing inflammatory pain and acts as a natural painkiller [46].

Fresh aloe vera gel contributed to the reduction of acute infection in rats caused by carrageenan, whereas leaf extract (5% homogenate) reduced arthritis by almost 50% also in model studies with rats [46].

Anti-cancer properties

Literature suggests that aloe-emodin has antiproliferative and anti-carcinogenic properties in human cell lines, it has an effect on cell cancer in a pleiotropic manner. The most notable effects

of its use include inhibiting cell proliferation, migration and invasion, cycle arrest, induction of cell death and modulation of immune signaling. However, the effect of aloe-emodin is largely dependent on the type of cancer. It has been shown in clinical trials its beneficial effects against cancer of the tongue, lungs, ovary, prostate, stomach and skin [49].

Aloe vera juice makes it possible to cure not only cancer, but also due to damage caused by radio and chemotherapy, which destroys the healthy immune cells necessary for regeneration. Aloe Vera acts as a radiation protector and inhibits gamma damage by the nucleus [39]. Shalabi et al. [52] investigated the effects of aloe vera extract *in vitro* against hepatocellular carcinoma cells in humans. The extract used increased cytotoxicity to hepatocellular carcinoma cells in a time and dose dependent manner, its effect was mainly related to modulation of apoptosis.

Scientific studies have shown that aloe polysaccharide fractions inhibit the binding of benzo-pyrene to hepatocytes in rat organisms, thereby contributing to the prevention of the formation of potentially carcinogenic DNA adducts with benzopyrene [7, 30]. Another of aloe anthraquinones - aloin, has a chemoprotective effect on preneoplastic damage induced by colon 1,2-dimethylhydrazine in rats [55].

Wound healing

Maenthaisong et al. [32] report that the use of aloe vera has a beneficial effect on the treatment of I and II degree burns. In this research soaked gases with an aloe vera solution, aloe vera cream and 1% aloe vera powder with white vaseline jelly gauze have been used in patients with burns 2 - 40% total body surface area. Observations clearly indicated significant benefits from using aloe vera compared to the control treatment with vaseline swabs. In another research conducted by Moriyama et al. [37], both aloe vera gel and aloe vera extract were used to heal wounds. The obtained results confirm that these products significantly improved wound healing in human primary epidermal keratinocytes (PHEK) and in a model equivalent to human skin. These products also contributed to changes in the progression of the cell cycle, increase in the number of cells and cause their migration. In model studies on 63 male rats with wounds confirmed that the use of aloe gel (twice a day) increases wound healing power than in other groups [57].

Polysaccharides present in aloe vera gel (mainly acemannan) accelerate the wound healing process by increasing collagen synthesis and are involved in the production of hyaluronic acid and hydroxyproline in fibroblasts [40]. The use of aloe vera also affects the composition of collagen and its increased cross-linking, as a consequence its breaking strength is improved. In

addition, aloe vera contains significant amounts of water (96%), which prevents drying of wounds and increases the migration of the epithelial cells [38, 45].

Effect on cholesterol level

High blood cholesterol is the main risk factor for heart disease and stroke. Chandrakar et al. [9] studied the effect of aloe vera extract on serum cholesterol on male rats. The authors report that the study showed a significant decrease in serum cholesterol levels in all groups of rats treated with aloe vera, the significance level was 5% for the dose of 6 mg/kg and other doses, i.e. 3 mg/kg, 4 mg/kg and 5 mg/kg showed a significant decrease at the level of 0.1%, 0.5% and 0.2%, respectively. Research conducted by Dana et al. [14] also showed that aloe vera intake may be beneficial in controlling cholesterol levels and inflammation as the main risk factors for atherosclerosis. This experimental study was conducted on 32 New Zealand male rabbits, they were on high cholesterol diet (1% cholesterol). Rabbits in four experimental groups (n=8) were treated for 30 days: normal nutritional group, high cholesterol diet, high cholesterol diet with aloe vera gel (3.2% v/v per day in drinking water), and aloe vera with normal nutritional group. The results indicated that the use of aloe vera in the third group with high cholesterol diet significantly reduced total cholesterol and CRP than in the high cholesterol group ($p < 0.05$). The use of aloe vera along with a high cholesterol diet significantly reduced the formation of fatty streaks. Other research with oral use of aloe vera gel extract at a dose of 300 mg/kg body weight per day for diabetic rats over a period of 21 days showed a significant reduction in cholesterol and triglycerides levels in blood plasma [43].

Effect on digestive system

Aloe vera is well-known natural product in the fight against many different diseases of the digestive tract, especially recommended for digestive disorders and for the treatment of stomach ulcers [34]. Aloe juice is useful in the gastrointestinal problems, such as indigestion, yeast and alleviates digestive problems such as heartburn [39].

Studies have shown that supplementation of aloe gel in patients results in the reduction of liver damage caused by carbon tetrachloride [8]. Other data indicated the beneficial effect of acemannan on liver damage caused by alcohol [13]. Preliminary studies suggest that aloe vera gel (oral) may reduce symptoms and inflammation in patients with ulcerative colitis and support for the effect in inflammatory bowel disease [28].

Others

Aloe vera also plays an important role in the functioning of the immune system. Supplementation of the organism with aloe vera leads to an increase in macrophage cell viability and effectiveness in defense against pathogens. In studies on the macrophage cell line of mice, the stimulating effects of acemannan on the production of cytokines (cells involved in the immune response) were noticed. In comparison with other polysaccharides in aloe vera, the formation of leukocytes in the spleen and bone marrow in irradiated mice appears to be a characteristic reaction for acemannan. The immunomodulatory effect of aloe vera is not only associated with acemannan but also with glycoproteins, e.g. lectin. Due to the influence on the immunological activity of cells, aloe vera extracts appear to be very helpful in the treatment of AIDS patients [29].

Other studies support the antidiabetic activity of aloe vera [26]. In mice with this disease, five aloe phytosterols (lophenol, 24-methylphenol, 24-ethyl-lophenol, cycloartanol and 24-methylenecycloartanol) [58] showed anti-diabetic activity. Aloe vera contains insulin-boosting polysaccharides and hypoglycaemic properties. Its extract increases cell tolerance to glucose in normal and diabetic rats [46], and aloe juice used for 4 - 14 weeks showed significant hypoglycemic effect both, clinically and experimentally [18].

Recent research also report that aloe vera has also anti-obesity effects. Misawa et al. [35] analyzed the influence of aloe vera gel powder on rats with diet-induced obesity in two doses (20 and 200 mg/kg, every day) for 90 days. The authors observed a slight reduction in animal body weight by about 41% in both doses. It is suggested that regular intake of aloe vera juice helps maintain a healthy body weight, also provides a better mood, increases energy levels and is a natural help in detoxifying the body [44].

The moisturizing effects of aloe vera have also been demonstrated, aloe vera gel gloves were used in the treatment of dry skin associated with workplace exposure, where improved the integrity of the skin and reduced erythema [60]. It has also the ability to penetrate into its deeper layers, it smoothes and firms the skin, maintains moisture (muko-polysaccharides help in binding moisture in the skin), soothes and protects against the harmful effects of sunlight. It stimulates also the renewal of the epidermis and granulation of the connective tissue [12, 60]. Amino acids present in aloe vera cause softening of hardened skin cells, and zinc has astringent effect on tightening the pores [60]. All these elements make it can be used in the care of both dry, mature and acne skin. Aloe vera also plays a role in gerontology and rejuvenation of aging skin [12], is also used as a tonicity substance [46].

Possible side effects of use of aloe vera and its product

Some authors suggest, and thus abide, the side effects of concentrated aloe vera juice (long-term use or overdose). As a consequence, colonic atony and diarrhea with excessive loss of water and electrolytes (especially potassium) may occur. This caution is the result of research conducted on rats that have been drinking water with the addition of aloe vera extract every day for two years. In these studies, it was also observed that animals often suffered from benign or malignant cancers of the large intestine. However, the carcinogenic effect of aloe vera has not been confirmed in an experiment involving mice treated with decoction from this plant [12].

Aloe vera latex is known for its laxative properties. Anthraquinins present in latex are a powerful laxative, stimulate mucus secretion, increase intestinal water content and intestinal peristalsis [20]. After oral administration of aloe vera, components (mainly glycosides such as aloin A and B) that are not absorbed in the small intestine, are hydrolyzed in the colon by intestinal bacteria and then reduced to active metabolites (the main active metabolite is aloe-emodin-9-tron) [10], which has a stimulating and irritating effect on the gastrointestinal tract [Sahu]. Literature data also indicate that small amounts of active aloe vera compounds can pass into the milk of nursing mothers and then act laxative on infants [22].

Summary

The collected literature data show that aloe vera, as well as its products, mainly due to the bioactive compounds present in them, are characterized by a beneficial influence of human health in many ways. First of all, aloe has antioxidant, anti-inflammatory, anti-cancer, antimicrobial, immunomodulatory, lipid and blood sugar lowering properties, and also has a positive effect on wound healing and burns. Aloe vera is also an undoubtedly valuable ingredient in the field of cosmetics, which improves the condition of skin, hair and nails.

Despite many benefits for humans health, it is also important to pay attention to the possibility of side effects resulting from the use of aloe vera, mainly associated with the laxative effect. Due to the ambiguous results, both in the aspect of positive and negative effects of using aloe vera, scientific research should be continued not only with animals, but also in trials with humans.

References

1. Agarry OO, Olaleye MT, Bello-Michael CO. Comparative antimicrobial activities of Aloe Vera gel and leaf. *Afr J Biotechnol.* 2005; 4(12):1413-1414.
2. Ahlawat KS, Khatkar BS. Processing, food applications and safety of aloe vera products: a review. *J Food Sci Technol.* 2011; 48(5):525–533.
3. Amin K, Ozgen S, Selamoglu Z. Aloe Vera: a miracle plant with its wide-ranging applications. *Pharm Pharmacol Inter J.* 2018; 6(1):1-2.
4. Athiban PP, Borthakur BJ, Ganesan S, Swathika B. Evaluation of antimicrobial efficacy of Aloe vera and its effectiveness in decontaminating guttapercha cones. *J Conserv Den.* 2012; 15(3):246-248.
5. Azghani AO, Williams I, Holiday BD, Johnson AR. A Beta-linked mannan inhibits adherence of *Pseudomonas aeruginosa* to human lung epithelial cells. *Glycobiology.* 1995; 5(1):39-44.
6. Bawankar R, Singh P, Subramanian B. Bioactive compounds and medicinal properties of *Aloe vera* L.: An update. *J Plant Sci.* 2014; 2(3):102-107.
7. Boudreau MD, Mellick PW, Olson GR, Felton RP, Thorn BT, Beland FA. Clear evidence of carcinogenic activity by a whole-leaf extract of *Aloe barbadensis* miller (aloe vera) in F344/N rats. *Toxicol Sci.* 2013; 131(1):26-39.
8. Chandan BK, Saxena AK, Shukla S, Sharma N, Gupta DK, Suri KA, Suri J, Bhadauria M, Singh B. Hepatoprotective potential of *Aloe barbadensis* Mill. against carbon tetrachloride induced hepatotoxicity. *J Ethnopharmacol.* 2007; 111(3):560-566.
9. Chandrakar M, Palekar S, Chirade S, Fafiz SAM. Hypocholesterolemic effect of *Aloe vera* (L.) extract on high cholesterol fed calotes versicolor Daudin. *Asian J Exp Sci.* 2008; 22(3):295-298.
10. Che QM, Akao T, Hattori M, Kobashi K, Namba T. Isolation of human intestinal bacteria capable of transforming barbaloin to aloe-emodin anthrone. *Planta Med.* 1991; 57(1):15-19.
11. Choi S, Chung MH. A review on the relationship between Aloe vera components and their biologic effects. *Semin Integr Med.* 2003; 1:53-62.
12. Cieślak E, Turcza K. Właściwości prozdrowotne aloesu zwyczajnego *Aloe vera* (L.) Webb. (*Aloe barbadensis* Mill.). *Post Fitoter.* 2015; 2:117-124.
13. Cui Y, Ye Q, Wang H, Li Y, Yao W, Qian H. Hepatoprotective potential of Aloe vera polysaccharides against chronic alcohol-induced hepatotoxicity in mice. *J Sci Food Agr.* 2013; 94:1764-1771.
14. Dana N, Haghjooy Javanmard SH, Asgary S, Asnaashari H, Abdian N. Back to browse issues page anti-atherosclerotic effects of Aloe Vera in hypercholesterolemic rabbits. *JBUMS.* 2012; 14(4):34-37.
15. de Rodríguez DJ, Hernández-Castillo D, Rodríguez-García R, Angulo-Sanchez JL. Antifungal activity in vitro of Aloe vera pulp and liquid fraction against plant pathogenic fungi. *Ind Crop Prod.* 2005; 21(1):81-87.
16. El-Shemy HA, Aboul-Soud MA, Nassr-Allah AA, Aboul-Enein KM, Kabash A, Yagi A. Antitumor properties and modulation of antioxidant enzymes' activity by Aloe vera leaf active principles isolated via supercritical carbon dioxide extraction. *Curr Med Chem.* 2010; 17:129-138.
17. Femenia A, Sánchez ES, Simal S, Rosselló C. Compositional features of polysaccharides from Aloe vera (*Aloe barbadensis* Miller) plant tissues. *Carbohyd Polym.* 1999; 39:109–117.
18. Ghannam N, Kingston M, Al-Meshaal IA, Tariq M, Parman NS, Woodhouse N. The antidiabetic activity of Aloes: Preliminary clinical and experimental observations. *Horm Res.* 1986; 24(4):286-294.

19. Heggors P, Pineless GR, Robson MC. Dermaide Aloe/Aloe vera gel: Comparison of the antimicrobial effects. *Am J Med Technol.* 1979; 41:293-294.
20. Ishii Y, Tanizawa H, Takino Y. Studies of Aloe. V. Mechanism of cathartic effect. *Biol Pharm Bull.* 1994; 17(5):651-653.
21. Ito S, Teradaira R, Beppu H, Obata M, Nagatsu T, Fujita K. properties and pharmacological activity of carboxypeptidase in *Aloe arborescens* Mill. var. *Natalensis* Berger. *Phytother Res.* 1993; 7(7):26-29.
22. Jambor J. Zielarstwo w Polsce – stan obecny i perspektywy rozwoju. *Post Fitoter.* 2007; 2:78-81.
23. Joseph B, Justin Raj S. Pharmacognostic and phytochemical properties of *Aloe vera* Linn. - An overview. *Int J Pharm Sci Rev Res.* 2010; 2:106-110.
24. Kemp MC, Kahlon JB, Chinnah AD, Carpenter RH, McAnalley BH, McDaniel HR, Shan-non WM. In vitro evaluation of the antiviral effects of acemannan on the replication and pathogenesis of HIV-1 and other enveloped viruses: Modification of the processing of glycoprotein glycoprotein precursors. *Antiviral Res.* 1990; 13(1):83.
25. Kukułowicz A, Steinka I. Aloes – możliwość wykorzystania jako suplementu diety. *Probl Hig Epidemiol.* 2010. 91(4):632-636.
26. Kumar S, Yadav JP. Ethnobotanical and pharmacological properties of Aloe vera: A review. *J Med Plant Res.* 2014; 8:1387-1398.
27. Kwieciński A. Witaminy w leczeniu różnych schorzeń. *Farmaceutyczny Przegląd Naukowy.* 2007; 7-8:49-55.
28. Langmead L, Feakins RM, Goldthorpe S. Randomized, doubleblind, placebo-controlled trial of oral Aloe vera gel for active ulcerative colitis. *Aliment Pharm Ther.* 2004; 19:739-747.
29. Lin KY, Uen YH. Aloe-emodin, an anthraquinone, In vitro inhibits proliferation and induces apoptosis in human colon carcinoma cells. *Oncol Lett.* 2010; 1:541-547.
30. Lissoni P, Rovelli F, Brivio F, Zago R, Colciago M, Messina G, Mora A, Porro G. A randomized study of chemotherapy versus biochemotherapy with chemotherapy plus *Aloe arborescens* in patients with metastatic cancer. *In Vivo.* 2009; 23(1):171-175.
31. López A, de Tangil MS, Vega-Orellana O, Ramírez AS, Rico M. Phenolic constituents, antioxidant and preliminary antimycoplasmic activities of leaf skin and flowers of *Aloe vera* (L.) Burm. f. (syn. *A. barbadensis* Mill.) from the Canary Islands (Spain). *Molecules.* 2013; 18(5):4942-4954.
32. Maenthaisong R, Chaiyakunapruk N, Niruntraporn S. The efficacy of Aloe vera for burn wound healing: A systematic review. *Burns.* 2007; 33(6):713-718.
33. Mariita RM, Orodho JA, Okemo PO, Kirimuhuzya C, Otieno JN, Magadula JJ. Methanolic extracts of *Aloe Secundiflora* Engl. inhibits in vitro growth of tuberculosis and diarrhea-causing bacteria. *Pharmacognosy Res.* 2011; 3(2):95-99.
34. Matejczyk M, Golonko A, Chilmon E. Aloe vera – wybrane właściwości biologiczne. *Budownictwo i Inżynieria Środowiska.* 2017; 8(4):191-195.
35. Misawa E, Tanaka M, Nabeshima K, Nomaguchi K, Yamada M, Toida T, Iwatsuki K. Administration of dried Aloe vera gel powder reduced body fat mass in diet induced obesity (DIO) rats. *J Nutr Sci Vitaminol.* 2012; 58(3):195–201.

36. Moniruzzaman M, Rokeya B, Ahmed S, Bhowmik A, Khalil MI, Gan SH. In vitro antioxidant effects of *Aloe barbadensis* Miller Extracts and the potential role of these extracts as antidiabetic and antilipidemic agents on streptozotocin-induced type 2 diabetic model rats. *Molecules*. 2012; 17:12851-12867.
37. Moriyama M, Mariyama H, Uda J, Kubo H, Nakajima Y, Goto A, Akaki J, Yoshida I, Matsuoka N, Hayakawa T. Beneficial effects of the genus *Aloe* on wound healing, cell proliferation, and differentiation of epidermal keratinocytes. *PLoS One*. 2016; 11(10):1-15.
38. Mortan JF. Folk uses and commercial exploitation of *Aloe vera* leaf pulp. *Econ Bot*. 1961; 15:311-319.
39. Nandal U, Bhardwaj RL. *Aloe vera* for human nutrition, health and cosmetic use - A review. *Int Res J Plant Sci*. 2012; 3(3):038-046.
40. Pugh N, Ross SA, ElSohly MA, Pasco DS. Characterization of aloeride, a new high-molecular-weight polysaccharide from *Aloe vera* with potent immunostimulatory activity. *J Agric Food Chem*. 2001; 49(2):1030-1034.
41. Radha MH, Laxmipriya NP. Evaluation of biological properties and clinical effectiveness of *Aloe vera*: A systematic review. *J Tradit Complement Med*. 2014; 5(1):21-26.
42. Rahmani AH, Aldebasi YH, Srikar S, Khan AA, Aly SM. *Aloe vera*: Potential candidate in health management via modulation of biological activities. *Pharmacognosy Rev*. 2015; 9(18):120-126.
43. Rajasekaran S, Ravi K, Sivagnanam K, Subramanian S. Beneficial effects of *Aloe vera* leaf gel extract on lipid profile status in rats with streptozotocin diabetes. *Clin Exp Pharmacol P*. 2006; 33:232–237.
44. Rajeswari R, Umadevi M, Sharmila Rahale C, PushpaI R, Selvavenkadesh S, Sampath Kumar KP, Bhowmik D. *Aloe vera*: the miracle plant its medicinal and traditional uses in India. *J Pharmacogn Phytochem*. 2012; 1(4):118–124.
45. Reddy Uma CH, Reddy SK, Reddy J. *Aloe vera* - A Wound Healer. *Asian J Oral Health Allied Sci*. 2011; 1:91-92.
46. Sahu PK, Giri DD, Singh R, Pandey P, Gupta S, Shrivastava AK, Kumar A, Pandey KD. Therapeutic and medicinal uses of *aloe vera*: a review. *Pharmacol Pharm*. 2013; 4:599-610.
47. Saini M, Goyal PK, Chaudhary G. Anti-tumor activity of *Aloe vera* against DMBA/croton oil-induced skin papillomagenesis in Swiss albino mice. *J Environ Pathol Toxol Oncol*. 2010; 29(2):127-135.
48. Sanchez-Machado DI, Lopes-Cervantes J, Sendon R. *Aloe vera*: Ancient knowledge with new frontiers. *Trends Food Sci Tech*. 2017; 61:94-102.
49. Sanders B, Ray AM, Goldberg S, Clark T, McDaniel HR, Atlas SE, Farooqi A, Konefal J, Lages LC, Lopez J, Rasul A, Tiozzo E, Woolger JM, Lewis JE. Anti-cancer effects of *aloe-emodin*: A systematic review. *J Clin Trans Res*. 2017; 3(4):1-14.
50. Saoo K, Miki H, Ohmori M, Winters WD. Anti-viral activity of *Aloe* extracts against cytomegalovirus. *Phytother Res*. 1990; 10(4):348- 350.
51. Saritha V, Anilakumar KR, Khanum F. Antioxidant and antibacterial activity of *Aloe vera* gel extracts. *Int J Pharm Biol Arch*. 2010; 1(4):376-384.
52. Shalabi M, Khilo K, Zakaria MM, Elsebaei MG, Abdo W, Awadin W. Anticancer activity of *Aloe vera* and *Calligonum comosum* extracts separately on hepatocellular carcinoma cells. *Asian Pac J Trop Biomed*. 2015; 5(5):375-381.

53. Shireen F, Manipal S, Prabu D. Anti-fungal activity of Aloe vera: In vitro study. *SRM J Res Dent Sci*. 2015; 6(2):92-95.
54. Sitara U, Hassan N, Naseem J. Antifungal activity of aloe vera gel against plant pathogenic fungi. *Pak J Bot*. 2011; 43(4):2231-2233.
55. Suboj P, Babykutty S, Srinivas P, Gopala S. Aloe emodin induces G2/M cell cycle arrest and apoptosis via activation of caspase-6 in human colon cancer cells. *Pharmacol*. 2012; 89:91-98.
56. Sydiskis RJ, Owen DG, Lohr JL, Rosler KH, Blomster RN. Inactivation of enveloped viruses by anthraquinones extracted from plants. *Antimicrob Agents Ch*. 1991; 35(12):2463-2466.
57. Takzare N, Hosseini M, Hasanzadeh G, Mortazavi H, Takzare A, Habibi P. Influence of Aloe Vera gel on dermal wound healing process in rat. *Toxicol Mech Methods*. 2009; 19:73–77.
58. Tanaka M, Misawa E, Ito Y, Habara N, Nomaguchi K, Yamada M, Toida T, Hayasawa H, Takase M, Inagaki M, Higuchi R. Identification of five phytosterols from Aloe vera gel as antidiabetic compounds. *Biol Pharm Bull*. 2006; 29(7):1418-1422.
59. Waller J, Klopfenstein TJ, Poos M. Distillers feeds as protein sources for growing ruminants. *Anim Sci J*. 1980; 51(5):1154-1167.
60. West DP, Zhu YF. Evaluation of Aloe vera gel gloves in the treatment of dry skin associated with occupational exposure. *Am J Infect Control*. 2003; 31(1):40-42.
61. Yeh GY, Eisenberg DM, Kaptchuk TJ, Phillips RS. Systematic review of herbs and dietary supplements for glycemic control in diabetes. *Diabetes Care*. 2003; 26(4):1277-1294.
62. Zhang L, Tizard IR. Activation of mouse macrophage cell line by acemannan; the major carbohydrate fraction of Aloe vera. *Immunopharmacol*. 1996; 35:119-128.